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NOTES ON MATING AND REPRODUCTIVE SUCCESS OF *CEROPELMA LONGISTERNALIS* (ARANEAE, THERAPHOSIDAE) IN CAPTIVITY

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ABSTRACT. The reproductive success of a mating pair of *Ceropelma longisternalis* is reported. Courtship and mating behaviour are described. The female molted, mated, built a retreat, and made a free egg sac under laboratory conditions. For 49 days she remained in the retreat, until the juveniles emerged. Courtship, mating and egg production are discussed and compared with data from other Mygalomorphae.

The biology of Theraphosidae in particular, and Mygalomorphae in general, has not been studied as thoroughly as that of the Araneomorphae. The state of Mygalomorphae systematics is confusing and has only recently been globaly focused (Raven 1985). Baerg (1928, 1958) carried out the first biological studies on theraphosid natural history; and more recently Minch (1978a, b, c; 1979a, b) studied *Aphonopelma chalcodes* Chamberlin intensively. The Theraphosidae is a predominantly South American family, yet the biology of most South American species is unknown. Brazil & Vellard (1926) and Bücherl (1951; 1952) described the reproductive biology of several species, but only as addenda to medical or systematic objectives. Galiano (1969; 1973a, b; 1984) and Célérier (1986a) described the postembryonic development and the life cycles of several species, including *Ceropelma longisternalis* Schiapelli & Gerschman (Galiano 1973a). In spite of the frequent breeding and commercialization of "tarantulas" in many parts of the world, information on reproduction obtained through mating in the laboratory is only know from a brief note of Célérier (1986b).

The present paper initiates a series of studies on the biology of some Uruguayan Mygalomorphae, contributing information regarding the reproductive biology of *C. longisternalis*, a relatively small-sized theraphosid spider (9.7 mm carapace length). We describe the reproductive success of a female that molted and mated in the laboratory.

METHODS

An adult female and an adult male *C. longisternalis* were captured in the Sierra de las Animas, Maldonado, Uruguay, on 17 March and 18 April 1989, respectively. They were maintained separately in the laboratory in plastic petri dishes (14.0 cm in diameter and 1.5 cm high) with wet cotton wool. *Tenebrio* sp. larvae (Coleoptera) and cockroach *Blaptica dubia* juveniles were provided weekly for food. The female molted on 23 March 1989, reverting to a virgin. Maximum and minimum room temperatures were recorded daily. Room temperature, during captivity until mating, was maintained close to 25 °C; thereafter it was more variable (Fig. 1). After copulating the female was placed in a cylindrical glass jar measuring 17.0 cm in diameter and 6.0 cm high, with a lid, and containing a 3 cm deep layer of soil. She was fed mealworms and cockroaches *ad libitum*, and provided with a small container with water.

OBSERVATIONS

On 20 April 1989 the male and female were placed together: the plastic petri dish with the female was placed inside a larger cylindrical container (17.0 cm diameter and 6.0 cm high) and the lid was removed. Ten minutes later the male was gently placed in the container. He advanced slowly and soon made contact with the female. The male's courting behavior was characterized by palpal drumming (up and down alternating movements of the palpi touching the substratum) and body vibrations (probably caused by inward contractions of the third legs). The female raised her body threateningly, extended the palpi and forelegs upwards and opened her chelicerae. The male tapped the female with his forelegs and, pushing, clasped with his tibial spurs the female's open fangs. The female's fangs penetrated be-

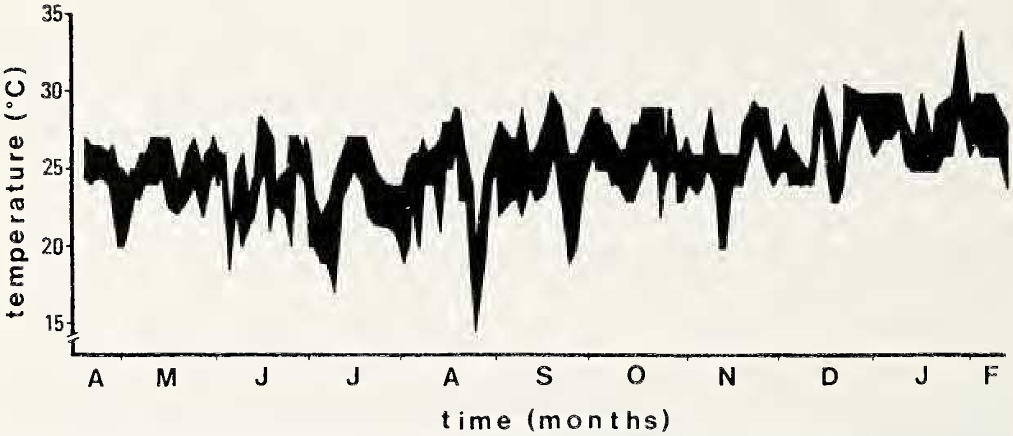
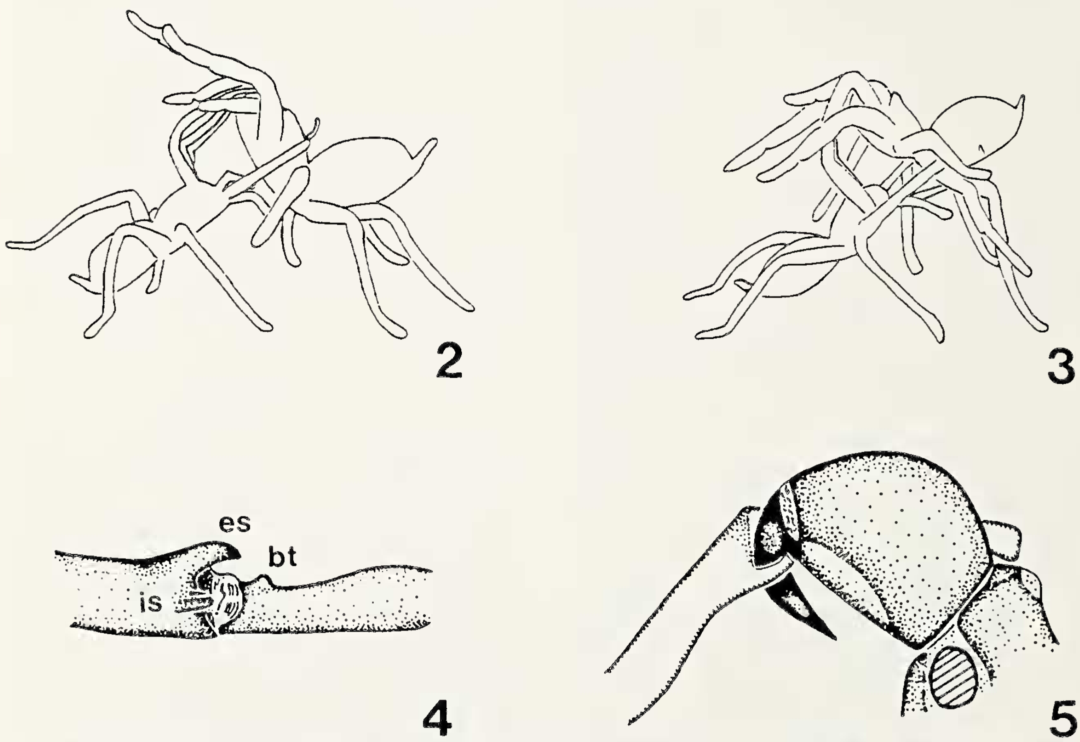


Figure 1.—Room temperature variations during maintainance of copulated female *Ceropelma longisternalis*; the superior line represents maximum daily temperatures and the inferior line minimum daily temperatures.

tween the external and the internal spurs, by the retrolateral side of male forelegs, and closed around the external apophysis (Figs. 2–5). The basal tubercle of each foreleg metatarsus apparently helped hold the female's fang while the metatarsus and tarsus remained against the basal joint of her chelicera. The male's second legs surrounded the female cephalothorax and pulled



Figures 2–5.—Copulation in *C. longisternalis*: 2, Initial copulation position (drawing obtained from a photograph). The male (at left) grasps the female cheliceral fangs with the foreleg tibial spurs while surrounding and attracting her with second legs; 3, The male attempts to insert the left palpus while the female (at right) rises over the male (drawing obtained from another photograph); 4, Ventral view (slightly prolateral) of tibial metatarsus joint of male right foreleg showing external (es) and internal (is) tibial spurs, and metatarsal basal tubercle (bt); 5, Male right foreleg (at left) clasping female left cheliceae (at right), lateral view. Drawn from photographs, notes and a reconstruction using preserved specimens.

it towards him to raise the female, so that the male palpi could approach the female genital zone (Fig. 2). Legs III and IV of both spiders were responsible for equilibrium. The male palpi oscillated in alternate fashion barely touching the female's abdomen while the male placed himself underneath; initially the female lifted the abdomen a little avoiding contact with the extended male palpi (Fig. 3).

Palpal insertions alternated regularly beginning with the left palpus. There were five insertions and the average duration of each was 50 s. The female initiated weak leg movements 105 s after commencement of copulation. Male body vibrations were also recorded after three min (during the fourth palpal insertion). The mating pair partially lost its balance twice, 20 s and 306 s after commencing copulation; following the latter the female increased leg movements and the male moved backwards freeing the female from his grasp. An immediate new encounter showed an active but non-aggressive female but did not involve any clasping attempts by the male. Copulation measured from the first insertion lasted 5.3 min. Room temperature during copulation was 23 °C. The male copulated one and four days later with two other females.

The mated female mounded soil against one side of the container and built a retreat there against the glass so that we could partially observe her activity. The retreat was lined with silk and its ceiling was against the lid. The female reconstructed this silk ceiling each time it was destroyed when we opened the jar to provide food. Towards the beginning of spring (27 September, 160 days after copulation), the female built a white oval egg sac with a 2.0 cm maximum diameter. The egg sac was not attached to the retreat and the female kept her palpi and legs in contact with it. Juveniles emerged 49 days following oviposition. We then opened the retreat, counted the juveniles, measured the retreat, returned the juveniles to the female, and closed the container (duration of manipulation: 40 min). Only 16 juveniles were found (three of them with exuviae remains still attached) and 10 exuviae adhered to the retreat's silk. The egg sac silk capsule was not analysed and remained pressed against the end of the retreat. The retreat's characteristics were as follows: large silk capsule over ground surface measuring 15.0 cm long, 3.5 cm wide and 2.0 cm high, limited on top by the lid, on the sides by the glass wall and towards the center of the container by the soil accumulated with silk. This capsule connected with the underground portion through a hole of approximately 2.5 cm diameter. The underground portion, extended horizontally along the bottom of the container and measured 7.0 cm long, 2.3–3.2 cm wide and 2.3–4.0 cm high.

The female did not rebuild the silk capsule following manipulation or expel the egg sac's covering. Juveniles were frequently seen out of the retreat 22 days after emergence. The female molted 85 days after emergence of juveniles (8 February 1990, summer). Two juveniles still remained in the retreat. The observations ended four days later.

DISCUSSION

Immediate contact between male and female prevented us from noticing whether the male can detect the presence of a female by contact with her silk. Nevertheless, one of us (Costa) observed a sexual response in this and other male *C. longisternalis* when placed on female silk. Male behavior was: brusque frontward and downward pushing movements of his body, which quickly drew back keeping the tarsi fixed on the ground. Platnick (1971) considered male Theraphosidae capable of sexual recognition only by direct contact with females (level I). But other authors have observed courting responses in males in the presence of conspecific female silk: Baerg (1958) in *Dugesiella hentzi* (Girard) and Minch (1979b) in *Aphonopelma chalcodes* Chamberlin, and also one of us (Costa) in species of *Grammostola* Simon, *Eupalaestrus* Pocock, *Oligoxystre* Vellard, *Acanthoscurria* Ausserer and *Homeomma* Ausserer. These observations suggest that tacto-chemical recognition is widespread in the family.

Male *C. longisternalis* movements (palpal drumming, body vibrations and advancing with forelegs raised) when placed before the female, female movements (threatening with palpi and forelegs, raised body, half-open chelicerae) and combined movements (tapping and entwining forelegs) are similar to the courtship movements observed in other Theraphosidae and other Mygalomorphae. Probably these movements constitute species-specific stimuli transmitted via acoustic and/or vibratory channels (through the substratum) and the tacto-chemical channel during physical contact. The apparently threatening female response is a necessary condition for copulation enabling the male to grasp the female's fangs with his foreleg tibial spurs. This peculiar grasp is the rule in Theraphosidae (Baerg 1928, 1958; Minch 1979b; Bergo & Abe 1985; Costa [pers. obs. in several Uruguayan species]), and was also reported for *Nemesia caementaria* (Latreille), Nemesiidae, by Buchli (1962), and for *Australothele jamiesoni* Raven, Dipluridae, by Raven (1988). It is surprising that Brazil & Vellard (1926) and Bücherl (1951) did not deseribe this conspicuous cheliceral clasping in *Grammostola* spp.

The simultaneous attraction of legs II and the fastening of forelegs onto the female chelicerae neutralizes these dangerous instruments and positions the genital zone within reach of the male palpi. A similar male attraction, either of the body or of the basal part of the female's legs, has not been indicated in Theraphosidae, although already reported in Dipluridae: *Euagrus* sp., Coyle (1986) and *Australothele jamiesoni*, Raven (1988); in Hexathelidae: *Macrothele calpeiana* (Walckenaer), Snazell & Allison (1989); in Nemesiidae: *Nemesia caementaria*, Buchli (1962) and *Acanthogonatus tacuariensis* (Pérez-Miles & Capocasale), Costa, pers. comm. *in* Pérez-Miles & Capocasale (1982).

Coyle (1985) briefly reviewed the different types of sexual embrace in Mygalomorphae. Grasping with legs II in *C. longisternalis* seems to disturb the couple's equilibrium. Clasping of chelicerae forces this species to assume a raised position, incompatible with copulation in the safety of the usual narrow burrows of the females. Consequently we would expect copulation to occur at the burrow entrance, as Minch (1979b) observed for *Aphonopelma chalcodes*. The increased risk of mating in an exposed situation would be compensated for by the brief duration of copulation.

Baerg (1928, 1958) observed in *Eurypelma californica* Ausserer and *Dugesiella hentzi* between 1–4 alternating palpal insertions in one minute. Minch (1979b) reported an average of seven alternating insertions during 2.3 min in *A. chalcodes*. The *C. longisternalis* eopulation was longer than in these spiders, but the number of insertions was intermediate between them.

Postcopulatory attack, and subsequent cannibalism, by the female was reported by Brazil & Vellard (1926) and Bücherl (1951, 1952) in several South American Theraphosidae. Our observations on *C. longisternalis* and other Uruguayan Theraphosidae show that males escape undamaged after copulation. Bücherl (1951, 1952) stressed as exceptional the absence of female cannibalism in *Grammostola mollicoma* (Ausserer) and *G. longimana* Mello-Leitao. Bergo & Abe (1985) reported a similar fact in *Pamphobeteus sorocabae* Mello-Leitao, a species cited by Bücherl (1952), however, as a postnuptial devourer. Multiple copulation by males, a phenomenon observed in this study and common in Uruguayan theraphosids and other mygalomorphs (Baerg 1928, 1958; Minch 1979b; Coyle 1986; Coyle & O'Shields 1990) may be in part the result of pronounced female longevity and a resultant high ratio of adult females to adult males (Coyle 1986).

The closed retreat built by *C. longisternalis* when overwintering and laying eggs is similar to the closed burrows observed by others: Baerg (1958) in *D. hentzi*, Gabel (1972) in a non-determined "tarantula", and Minch (1979a) in *A. chalcodes*. In the field juveniles and non-reproductive females *C. longisternalis* build simple silk tubes under stones, with little or no underground component. The construction reported here probably improves clutch viability by damping external thermal and humidity variations. Its reconstruction ceased with the emergence of juveniles. Duration of egg sac incubation is comparable with that indicated by Bücherl (1951) in *Grammostola* spp., Ibarra-Grasso (1961) in *G. burzaquensis* Ibarra-Grasso, Baerg (1958) and Whitcomb & Weems (1976) in *Dugesiella hentzi*, but shorter than that indicated by Brazil & Vellard (1926) in *Grammostola* spp.

The very low number of juveniles emerging from the egg sac may be due to laboratory conditions. Two *C. longisternalis* egg sacs of similar size obtained in the field contained 103 and 111 eggs, with an average diameter of 1.7 mm. Larger species of Theraphosidae lay more eggs: the small *Grammostola burzaquensis* lays 100–200 eggs (Ibarra-Grasso 1961), the large *Acanthoscurria atrox* Vellard up to 2000 eggs (Lourenço 1978) and the large *Pamphobeteus* spp. between 1200–2000 eggs (Bücherl 1951; Valente *et al.* 1985). The postreproductive molt seems to occur later in *C. longisternalis* than in other species (Brazil & Vellard 1926; Bücherl 1951).

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